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# "EXPERIMENTAL STUDY OF BEHAVIOUR AND STRENGTH OF FERROCEMENT RECTANGULAR BEAMS IN SHEAR"

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## ABSTRACT

Ferrocement is another form of reinforced concrete in which the cement mortar is reinforced with closely spaced layers of continuous and relatively small diameter wire mesh. Early applications of ferrocement have been to building of boats. Its application to terrestrial structures started much later.

The experimental investigation includes casting and testing of 24 rectangular beams and 8 cubes.The specimens were divided into eight series, A to H according to the volume fraction of reinforcement, compressive strength of the mortar, and amount of reinforcement was varied in Series A to H by varying the number of layers of wire mesh. Specimens in these series were symmetrically reinforced with 4, 6, 8 and 10 layers of wire mesh, respectively, and were lumped together near each face with a clear cover of 5 mm as shown in Figure 3.1. Series E and F were identical to Series D except for the compressive strength of the mortar. The remaining two Series G and H were also identical to Series D, but the amount of reinforcement near the compression face was different (Figure 3.1). While the specimens in Series H were provided with two layers of wire mesh, those in Series G contained no reinforcement near the compression face. The parameter investigated in each series was the shear-span-to-depth ratio a/h, which was achieved by varying the shear-span-to-overall-depth ratio from 1 to 2 at increments of 0.5 for the sake of simplicity since several reinforcement layers were involved.

**KEYWORDS:** Ferrocement, Flexural Strength, Moment Curvature, Shear Resistance, Shear Cracks

## INTRODUCTION

An important development that has recently occurred is the recognition of ferrocement as a material suitable for construction in developing countries. In particular, the application of ferrocement for housing is increasingly recognized as a viable alternative to conventional construction. After Second World War, Nervi demonstrated the utility of ferrocement as a boat building material by building the 165 ton mortar sailor Irene with a 3.6 cm thick ferrocement hull. He reported that the weight of the vessel was approximately 5% less than an equivalent wooden ship and its cost was 40% less compared to a similar wooden hull.

Abdulla and Katsuki Takiguchi[3] have conducted experimental study on wear of concrete by Ferrocement boxes. The test results indicate that ferrocement boxes offer significant enhancement in stiffness, strength and ductility. Al-Kubaisy and Ned Well[1] studied on the location of the diagonal crack in ferrocement rectangular beams. The variables covered in the study were, a/d volume fraction and compressive strength of the mortar '$f_{cu}$'. The results indicated that the location of the critical diagonal crack as measured from the nearest support increases as the a/d ratio is increased and to a

lesser extent as ‘$f_{cu}$’ is decreased.

Abdul Samad, Rashid, Megat Johari, and Abang Abdulla[3] investigated on the ferrocement box beams subjected two point load tests which induces pure bending moment with shear force. The modes of failures and crack pattern were observed. The lower the a/d ratio (≤1) the more prominent is the diagonal tension failure, for the higher value of a/d (>1) tends to develop flexural failure of the beam. The ferrocement box section beams have very high shear capacity. With very low a/d ratio (0.7).

Mansur, M.A. and Ong, K.C.G. 1987[4] conducted shear tests on the ferrocement Channel sections and concluded that, the behaviour of these structural sections is similar to that of structural reinforced concrete sections.

One of the important applications of ferrocement is to roofing. Considerable amount of information is available on the flexural strength of ferrocement roofing elements, but not much work has been done on the shear strength of such elements. Hence, there is a need to know the strength and behaviour of ferrocement in shear and to develop design guide lines for the same. It is to be mentioned here that the ACI Committee 549 report on guide for the design, construction, and repair of ferrocement does not contain any suggestion for shear strength determination, the reason for this being, not much test data and research information is available on the same. Hence, the problem of shear in ferrocement has been chosen for the present study.

Some investigations of exploratory nature on the shear strength of ferrocement specimens have been recently reported. Detailed studies on the same covering the different constituents of ferrocement over full ranges of parameters have been come across in the literature. For instance, no attempts have been reported to predict the shear strength of ferrocement rectangular specimens reinforced with wire meshes.

Keeping this in view, the present study was focussed towards understanding the strength and shear behaviour of ferrocement as a material.

## EXPERIMENTAL INVESTIGATION

### Materials

The Materials used in this study are cement, sand, water, welded wire mesh.

### 1.1 Cement

Ordinary Portland cement (OPC-43 grade) of Grasim industries Ltd. from a single batch was used throughout the course of the investigation.

### 1.2 Sand

Well graded locally available river sand from Shahpur taluka of 2.36 mm size was used, lumps of clay were separated out from the sand. The grading of sand for mortar mixes becomes very important to get workable cement mortar with low w/c ratio. The analysis of the sand used is carried out to find the FM of the sand.

### 1.3 Water

Water used for both mixing and curing should be free from injurious amounts of deleterious materials. Potable water is generally considered satisfactory for mixing and curing of concrete. In the present work potable tap water is used.

### 1.4 Welded Wire Mesh

Wire mesh is one of the important constituent of Ferrocement. This generally consists of thin wires. The Mechanical Properties of ferrocement depends upon the type quantity and strength properties of mesh reinforcement.

The wire mesh used in this study is of square pattern with an opening of 12.5 mm x 12.5 mm and having a diameter of 1.2 mm. The yield strength in tension for the wire mesh was 410 N/mm$^2$. The different types of wire meshes are square woven or welded meshes, chicken (Hexagonal/aviary) wire mesh, expanded metal mesh lath etc. Except for expanded metal mesh, generally all the meshes used are galvanized. The properties of wire mesh are tabulated in (table 1.1 below) figure 3.2 depicts the typical steel wire meshes used in ferrocement.

**Table 1.1: Properties of Wire Mesh**

| Wire Mesh Type | Properties | Values |
|---|---|---|
| Welded wire mesh | Average diameter<br>opening size of mesh<br>yield strength in tension modules of elasticity | 1.2 mm<br>12.5mmx12.5mm<br>410 N/mm$^2$<br>10000 N/mm$^2$ |

**The photographic view of the wire mesh used in this project is given below:**

**Figure 1.1: Square Welded Wire Mesh**

### 2. Mix Proportions

Throughout the whole program the cement to sand ratio was 1:2. The w/c ratios used were 0.45 and 0.55 for the Series E and F, respectively, and 0.50 for the remaining series to achieve different compressive strengths of the mortar.

### 3. Mixing Method

The mixing procedure is almost the same as adopted for Normal cement mortar matrix. Finally, the following mixing sequence was followed.

- Add fine aggregate + cement
- Dry Mixing for about 10-30 seconds
- Add Water
- Final mixing until a mortar of uniform colour and consistency is obtained

**4. Casting and Curing**

The different ingredients of cement mortar viz. cement and sand in dry state and weigh them as per the mix design requirements. The requisite amount of weighed sand and cement is initially taken and is mixed in a dry state to get a uniform mix.

All the materials are again thoroughly mixed until a uniform colour appeared. As per the mix design calculations the requisite amount of water is added to dry mix of cement and sand. After addition of water and all the ingredients are thoroughly mixed to get a homogenous mix.

The plywood moulds of size (600mmx150mmx75mm) of best quality were made to order. Before pouring the fresh cement mortar in these moulds a nominal cover of 5 mm is provided to the mesh reinforcement, an engine oil is applied in thin layers to the inner surfaces of moulds in order to prevent the sticking of cement mortar to mould. These specimens are allowed to set in the moulds for 24 hours, after 24 hours these specimens are de-moulded and were kept under wet conditions by immersing them in water continuously for 14 days.

**5. Test SET UP**

All beams were simply supported on the two edges. The beams were white washed to assist in crack detection. All specimens were tested under two symmetrical point loads in universal testing machine.

The deflection under the load point was measured and a search was made for the appearance of cracks. Powerful lenses were also used in detecting the appearance of cracks. The early cracks progress and position was marked by using pencil and sketched by using permanent marker.

The load at initial crack for each test specimen is noted. After the Failure the ultimate load, mode of failure and cracking pattern were recorded.

**Figure 5.1: Test Setup**

## III.RESULTS & DISSCUSSIONS

**3.1 Results**

- Table 3.1 Details of test specimens.
- Table 3.2 – 3.13 the test results of various beams are tabulated.
- The load – deflection curves are drawn in (figure. 3.1, 3.2, 3.3, 3.4 & 3.5).

Figure 3.1: For beams of series A

Figure 3.2: For beams of series B

Figure 3.3: For beams of series C

Figure 3.4: For beams of series D

Figure 3.5: For beams of series E

Figure 3.6: For beams of series F

Figure 3.7: For beams of series G

Figure 3.8: For beams of series H

Figure 3.9 Regression analysis between $\frac{V_{cr}}{bh}$ and $\frac{f_{cu} V_f h}{a}$

**Table 3.1: Details of Test Specimen**

| Series * | Number of Layers of Wire Mesh | | Total Volume Fraction of Reinforcement in Longitudinal Direction $V_f$, Percent | Water-Cement Ratio | Cube Compressive Strength of Mortar, $F_{cu}$ N/Mm$^2$ |
|---|---|---|---|---|---|
| | Top | Bottom | | | |
| A | 2 | 2 | 0.482 | 0.50 | 34.42 |
| B | 3 | 3 | 0.823 | 0.50 | 34.42 |
| C | 4 | 4 | 0.965 | 0.50 | 35.56 |
| D | 5 | 5 | 1.206 | 0.50 | 35.56 |
| E | 5 | 5 | 1.206 | 0.45 | 44.33 |
| F | 5 | 5 | 1.206 | 0.55 | 24.13 |
| G | 2 | 5 | 0.844 | 0.50 | 35.63 |
| H | 0 | 5 | 0.603 | 0.50 | 35.63 |

**Table 3.2: Beams of Series A**

| Sl. No | Designation | Load(Kn) | Deflection in Mm |
|---|---|---|---|
| 1. | A1 | 11.3 | 12.7 |
| 2. | A 1.5 | 8.2 | 10.7 |
| 3. | A 2 | 6.8 | 9 |
| 4. | B1 | 13.3 | 13.4 |
| 5. | B 1.5 | 9.8 | 11.8 |
| 6. | B 2 | 8.4 | 10.8 |
| 7. | C1 | 15.2 | 14.2 |
| 8. | C 1.5 | 12.4 | 13.2 |
| 9. | C 2 | 10.9 | 12.2 |
| 10. | D1 | 18.8 | 14.2 |
| 11. | D 1.5 | 14.4 | 14 |
| 12. | D 2 | 11.2 | 12.5 |
| 13. | E1 | 20.2 | 14.4 |
| 14. | E 1.5 | 16.2 | 14.3 |
| 15. | E 2 | 12.8 | 12.5 |
| 16. | F1 | 16.2 | 11.9 |
| 17. | F 1.5 | 11.3 | 14.2 |
| 18. | F 2 | 10.2 | 13.5 |
| 19. | G1 | 18.2 | 12.8 |
| 20. | G 1.5 | 13.4 | 12.3 |

| Table 3.2: Contd., | | | |
|---|---|---|---|
| 21. | G 2 | 11.8 | 10.7 |
| 22. | H1 | 16.1 | 14.2 |
| 23. | H 1.5 | 12.3 | 13.7 |
| 24. | H 2 | 9.6 | 12.8 |

**Table 3.3: Test Results and Diagonal Cracking Strength**

| Sl. No | Beam Designation | Observed Cracking Load $V_{cr}$ (KN) | Observed Ultimate Load $V_u$ ( KN ) | $V_{cr}$/Bh N/Mm$^2$ |
|---|---|---|---|---|
| 1 | A | 7.633 | 8.766 | 0.678 |
| 2 | B | 8.70 | 10.50 | 0.764 |
| 3 | C | 10.40 | 12.833 | 0.930 |
| 4 | D | 11.70 | 14.80 | 1.03 |
| 5 | E | 13.666 | 16.40 | 1.214 |
| 6 | F | 10.366 | 12.566 | 0.921 |
| 7 | G | 11.333 | 14.466 | 1.007 |
| 8 | H | 8.60 | 12.666 | 0.882 |

**Table 3.4: Compressive Strength of Cubes ($F_{cu}$)**

| Si. No | Beam Designation | Water Cement Ratio | Load (Kn) | Compressive Strength in N/(Mm$^2$) |
|---|---|---|---|---|
| 1. | A | 0.50 | 171 | 34.42 |
| 2. | B | 0.50 | 171 | 34.42 |
| 3. | C | 0.50 | 177 | 35.56 |
| 4. | D | 0.50 | 177 | 35.56 |
| 5. | E | 0.45 | 221 | 44.33 |
| 6. | F | 0.55 | 121 | 24.13 |
| 7. | G | 0.50 | 178 | 35.63 |
| 8. | H | 0.50 | 178 | 35.63 |

**Table 3.5: Test Result**

| Sl. No | Beams Designation | Shear At Cracking $V_{cr}$ (KN) | Shear At Failure $V_u$ (KN) | Compressive Strength In (N/Mm$^2$) | Cracking Shear Stress $\tau_{Vcr} = \frac{V_{cr}}{bd}$ (N/Mm$^2$) | $\frac{V_{cr}}{bd\sqrt{f_{cu}}}$ |
|---|---|---|---|---|---|---|
| 1. | A | 7.6 | 8.7 | 34.42 | 0.78 | 0.1334 |
| 2. | B | 8.6 | 10.5 | 34.42 | 0.88 | 0.1503 |
| 3. | C | 10.4 | 12.8 | 35.56 | 1.06 | 0.1800 |
| 4. | D | 11.7 | 14.8 | 35.56 | 1.206 | 0.2012 |
| 5. | E | 13.6 | 16.4 | 44.33 | 1.40 | 0.2105 |
| 6. | F | 10.3 | 12.8 | 24.13 | 1.056 | 0.2164 |
| 7. | G | 11.3 | 14.4 | 35.63 | 1.16 | 0.1947 |
| 8. | H | 9.9 | 12.6 | 35.63 | 1.018 | 0.1706 |

**Table 3.6: Comparison of Test Cracking Load ($V_{cr}$) With Design Code**

| Sl. No. | Beam Designation | Test Cracking Load ($V_{cr}$) (KN) | Cracking Load in KN ACI 318- 83 | $\frac{V_{crtest}}{V_{crcode}}$ |
|---|---|---|---|---|
| 1. | A | 7.63 | 10.6 | 0.71 |
| 2. | B | 8.60 | 11.6 | 0.74 |
| 3. | C | 10.4 | 15 | 0.69 |
| 4. | D | 11.7 | 16 | 0.73 |
| 5. | E | 13.66 | 18.5 | 0.73 |
| 6. | F | 10.36 | 14 | 0.74 |
| 7. | G | 11.33 | 16 | 0.66 |
| 8. | H | 9.93 | 13 | 0.76 |
| **Mean** | | | | **0.720** |
| **S.D** | | | | **0.102** |

**Table 3.7: Comparison of Test Cracking Shear Stress ($\tau_{Vcr}$) With Design Code**

| Sl. No. | Beam Designation | Test Cracking Shear Stress $\tau_{Vcr}$ (N/Mm$^2$) | ACI-318-83 | $\frac{\tau_{vcrtest}}{\tau_{vcrcode}}$ |
|---|---|---|---|---|
| 1. | A | 0.78 | 1.08 | 0.72 |
| 2. | B | 0.88 | 1.19 | 0.74 |
| 3. | C | 1.06 | 1.53 | 0.45 |
| 4. | D | 1.26 | 1.64 | 0.73 |
| 5. | E | 1.40 | 1.90 | 0.73 |
| 6. | F | 1.056 | 1.43 | 0.73 |
| 7. | G | 1.162 | 1.64 | 0.66 |
| 8. | H | 1.018 | 1.33 | 0.76 |
| **Mean** | | | | **0.69** |
| **S.D** | | | | **0.104** |

**Table 3.8: Test Parameter Volume Fraction of Reinforcement ($V_f$) V/S $\frac{V_{cr}}{bh}$**

| Sl. No. | $V_f$ (%) | $\frac{V_{cr}}{bh}$ N/Mm$^2$ |
|---|---|---|
| 1 | 0.48 | 0.678 |
| 2 | 0.72 | 0.764 |
| 3 | 0.96 | 0.93 |
| 4 | 1.206 | 1.3 |
| 5 | 1.206 | 1.214 |
| 6 | 1.206 | 0.921 |
| 7 | 0.844 | 1.007 |
| 8 | 0.603 | 0.822 |

**Table 3.9: Test Parameter Shear Span to Depth Ratio (A/H) V/S $\frac{V_{cr}}{bh}$**

| Sl. No. | A/H Ratio | $\frac{V_{cr}}{bh}$ N/Mm$^2$ |
|---|---|---|
| 1 | A1 | 0.835 |
| 2 | A 1.5 | 0.648 |
| 3 | A 2 | 0.551 |
| 4 | B1 | 0.906 |
| 5 | B 1.5 | 0.746 |
| 6 | B 2 | 0.640 |
| 7 | C1 | 1.013 |
| 8 | C 1.5 | 0.960 |
| 9 | C 2 | 0.817 |
| 10 | D1 | 1.20 |
| 11 | D 1.5 | 0.995 |
| 12 | D 2 | 0.924 |
| 13 | E1 | 1.351 |
| 14 | E 1.5 | 1.28 |
| 15 | E 2 | 1.013 |
| 16 | F1 | 0.995 |
| 17 | F 1.5 | 0.897 |
| 18 | F 2 | 0.871 |
| 19 | G1 | 1.093 |
| 20 | G 1.5 | 0.995 |
| 21 | G 2 | 0.933 |
| 22 | H1 | 1.022 |
| 23 | H 1.5 | 0.871 |
| 24 | H 2 | 0.755 |

**Table 3.10: Test Parameter Mortar Strength ($F_{cu}$) V/S $\frac{V_{cr}}{bh}$**

| Sl. No. | Mortar Strength $F_{cu}$ (N/Mm$^2$) | $\frac{V_{cr}}{bh}$ |
|---|---|---|
| 1 | 34.42 | 0.678 |
| 2 | 34.42 | 0.764 |
| 3 | 35.56 | 0.93 |
| 4 | 35.56 | 1.3 |
| 5 | 44.33 | 1.214 |
| 6 | 24.13 | 0.921 |
| 7 | 35.63 | 1.007 |
| 8 | 35.63 | 0.822 |

**Table 3.11: Regression Analysis Between $\frac{V_{cr}}{bh}$ And $\frac{f_{cu} V_f h}{a}$**

| Sl. No. | $\frac{V_{cr}}{bh}$ | $\frac{f_{cu} V_f h}{a}$ |
|---|---|---|
| 1 | 0.678 | 0.150 |
| 2 | 0.764 | 0.20 |
| 3 | 0.93 | 0.258 |
| 4 | 1.3 | 0.310 |

| Table 3.11: Contd., | | |
|---|---|---|
| 5 | 1.214 | 0.40 |
| 6 | 0.921 | 0.210 |
| 7 | 1.007 | 0.217 |
| 8 | 0.822 | 0.175 |

**Table 3.12: Comparison of Observed and Predicted Cracking Shear Stress**

| Sl. No. | Beam Designation | Observed Shear Stress $\tau_{Vcrtest}$ in N/Mm$^2$ | Predicted Shear Stress $\tau_{Vcrpri}$ in N/Mm$^2$ | $\frac{\tau_{vcrtest}}{\tau_{vcrpri}}$ |
|---|---|---|---|---|
| 1 | A | 0.678 | 0.572 | 1.18 |
| 2 | B | 0.764 | 0.736 | 1.03 |
| 3 | C | 0.93 | 0.900 | 1.03 |
| 4 | D | 1.3 | 1.037 | 1.25 |
| 5 | E | 1.214 | 1.28 | 0.94 |
| 6 | F | 0.921 | 1.01 | 0.911 |
| 7 | G | 1.007 | 0.835 | 1.19 |
| 8 | H | 0.822 | 0.673 | 1.20 |
| **Mean** | | | | **1.050** |
| **S.D** | | | | **0.096** |

**Table 3.13: Comparison of Predicted Cracking Load Values ($V_{crpri}$) With Design Code ($V_{crcode}$)**

| Sl. No. | Beam Designation | Predicted Cracking Load ($V_{crpri}$)in KN | Cracking Load (ACI 318-83) ($V_{crcode}$) in KN | $\frac{V_{crpri}}{V_{crcode}}$ |
|---|---|---|---|---|
| 1. | A | 6.4 | 10.6 | 0.603 |
| 2. | B | 8.28 | 11.6 | 0.713 |
| 3. | C | 10.12 | 15 | 0.674 |
| 4. | D | 11.58 | 16 | 0.723 |
| 5. | E | 14.4 | 18.5 | 0.782 |
| 6. | F | 11.07 | 14 | 0.802 |
| 7. | G | 9.39 | 16 | 0.586 |
| 8. | H | 7.57 | 13 | 0.582 |
| **Mean** | | | | **0.683** |
| **S.D** | | | | **0.081** |

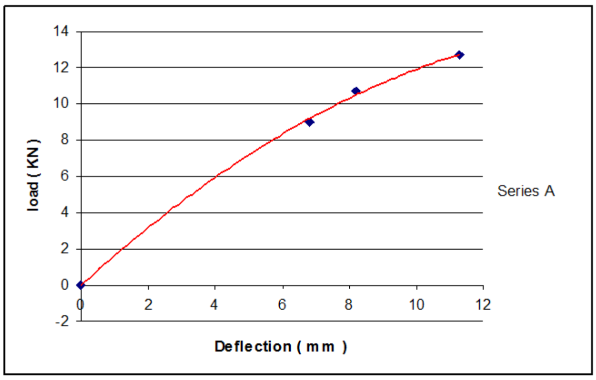


**Figure 3.1: For Beams of Series A**

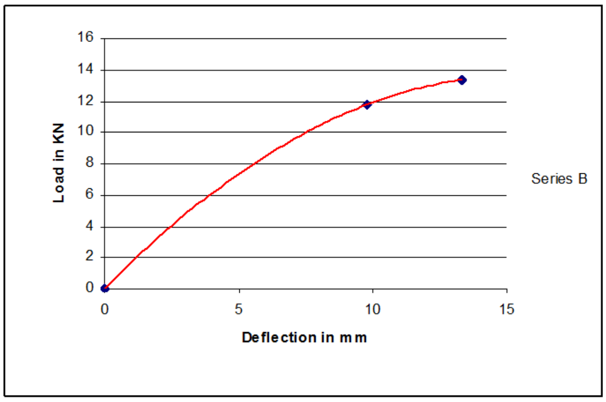


Figure 3.2: For Beams of Series B

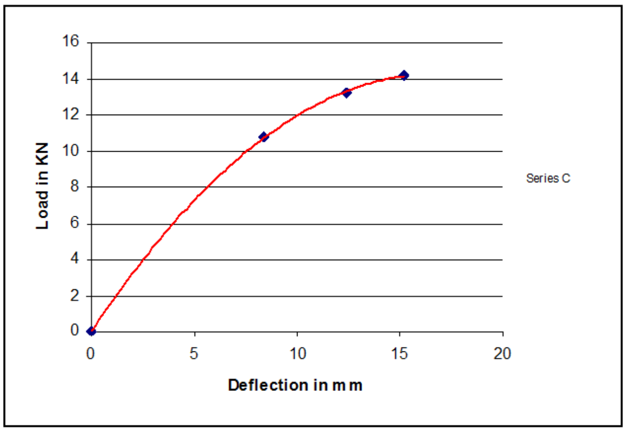


Figure 3.3: For Beams of Series C

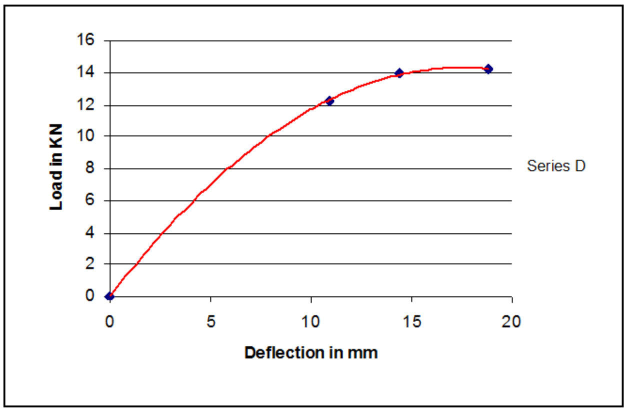


Figure 3.4: For Beams of Series D

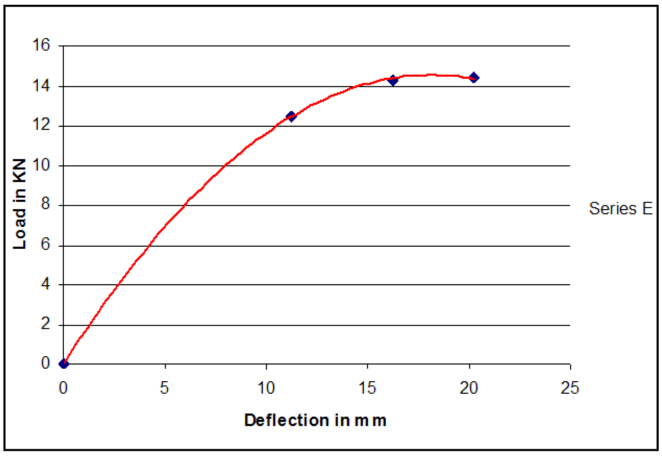


**Figure 3.5: For Beams of Series E**

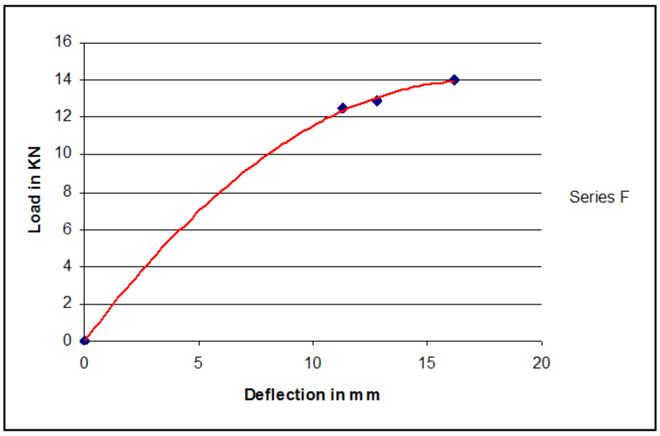


**Figure 3.6: For Beams of Series F**

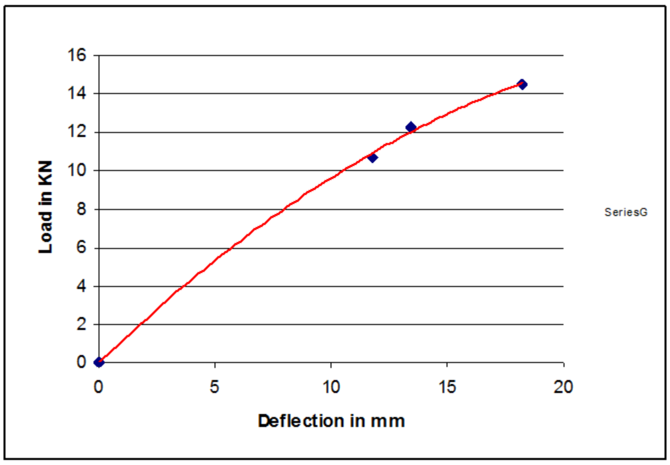


**Figure 3.7: For Beams of Series G**

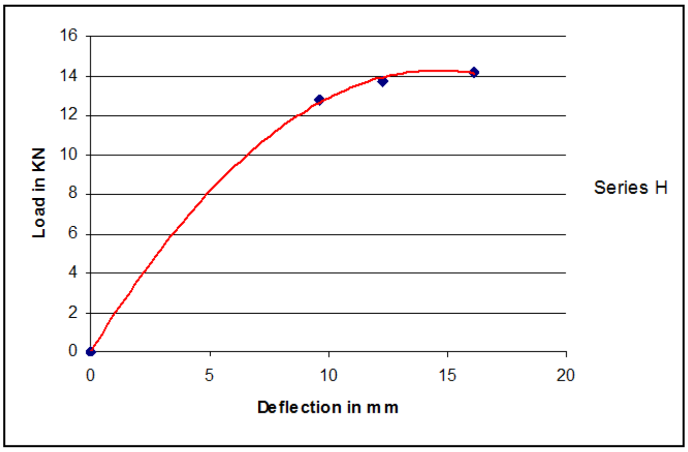


**Figure 3.8: For Beams of Series H**

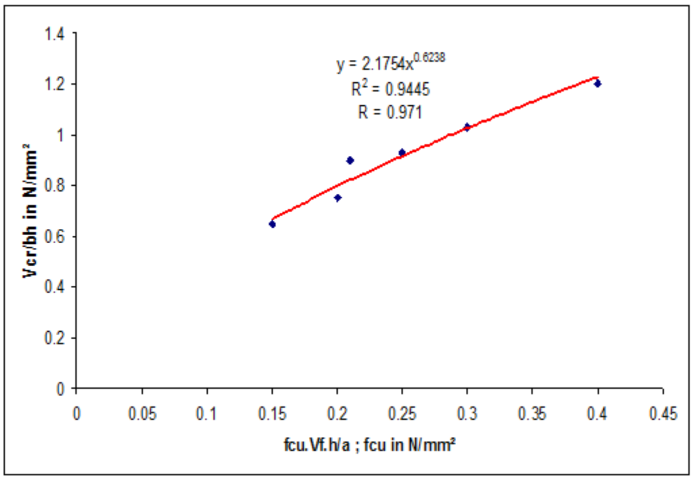


**Figure 3.9: Regression Analysis Between** $\frac{V_{cr}}{bh}$ **And** $\frac{f_{cu}V_f h}{a}$

## 3.2 DISCUSSIONS

The experimental results which were obtained in this project work are given in section 1.1. Based on the obtained results some of the salient points regarding the investigation process are discussed below.

### 3.2.1 Load Deflection Relationship:

The load-deflection curves for the tested beams are shown in figures.( 3.1-3.8 )

**Stage - I:** The load-deflection relationship is linear (Steepest Slope) before the cracking of the mortar.

**Stage - II:** The end of the linearity of the curve marked the begining of cracking as indicated by the deviation from the load-deflection relationship corresponding to the load increment. This shows a little flatter slope.

**Stage - III:** Finally in this stage, as the ultimate load is reached the cracks gets widened and the curve became almost parallel the deflection axis. At this stage the failure of specimen is clearly visible.

The end of stage-I occurred at a load of $0.70V_u$ to $0.90V_u$. The first crack was observed soon after reaching the load corresponding to the deviation from linearity of the slope at stage-I.

**4.2.2Cracking Behaviour and Modes of Failure**

In all specimens, flexural cracks occurred first irrespective of the study parameters of the presenet study. As the load was increased, additional vertical cracks appeared on beam surface, followed by the formation of diagonal cracks. A diagonal tension crack is generally defined as "An inclined crack in the shear span that extends from the tensile reinforcement towards the nearer concentrated load and intersects the compression reinforcement at an angle of approximately $45^0$".

In the present study , diagonal tension cracks in the specimens with a/h > 1.5 generally originated as vertical flexural cracks that extended from the tesile surface of the beam to slightly above the level of the bottom layer of wire mesh , then became inclined and propogated towards the nearer concentrated load.

With an increase in the applied load, the inclined portion of the diagonal tension crack also propogated downward with approximately the same slope as the original inclined crack.

In cases of beams with shorter shear span( a/h $\leq$ 1.5 ) , diagonal tension cracks originated at about mid-depth of the beam and then progressed towards nearer concentrated load and tensile reinforcement.

Formation of cracks did not immediately lead to final collapse.Instead , these cracks continued to develope with each increment of the applied load and the ultimate loads sustained by the beams is higher than the load at which diagonal tension crack first formed.

The type of failure was a true shear failure that occured in beams with a/h $\leq$ 1.5 . The compression zone of the mortar suddenly sheared off along well developed diagonal tension cracks in the shear span adjacent to the loading point. This type of failure occured along newly formed crack parallel to original diagonal crack at load slightly less than the maximum.

The other type of failure occured in beams with a/h = 2. This was typically shear compression failure charcterized by crushing of the mortar near the concentrated load.

Also the combination of the shear and flexural cracks simultaneously in shear span grew excessively wide , leading to the crushing of the mortar under the loading point.

The results of the series A to D show that an increase in the amount of reinforcement tends to induce shear failure. While all the specimens in the A-series that contained $V_f$ of 0.48 % failed in the flexural mode irrespective of the a/h ratios. Those with a/h $\leq$ 2 in series D ($V_f$ = 1.20 )failed either in shear or in shear-flexure. similarly ,a comparison of the results of series D,E,F and series D, G, H indicate that a decrease in the compressive strength of the mortar or an increase in the amount of reinforcement near the compression face of the beam also tends to induce shear failure. Hence shear failure is possible in ferrocement at a small a/h ratios, which becomes critical when a high volume fraction of reinforcement is used

in combination with a stronger mortar

**Figure 3.10: Shows Experimental Works**

## CONCLUSIONS

- The diagonal cracking strength of ferrocement increases as the a/h ratio is decreased or volume fraction of reinforcement and strength of the mortar are increased.
- An increase in the amount of reinforcement near the compression face also increases the diagonal cracking strength of a beam.
- The ACI building Code formula for conventional reinforced concrete beams provides highly conservative predictions of the diagonal cracking strength of ferrocement.
- The empirical formula ( $\frac{V_{cr}}{bh} = 2.1754\left(f_{cu} V_f \frac{h}{a}\right)^{0.624}$ ) proposed here interms of h and $V_f$ provide good predictions of the diagonal cracking strength for the entire range of variables considered in this study.
- In the case of symmetrically reinforced ferrocement beams, ( $\frac{V_{cr}}{bh} = 2.1754\left(f_{cu} V_f \frac{h}{a}\right)^{0.624}$ ), which is expressed in terms of h and $V_f$, may be used to calculate the diagonal cracking strength with sufficient accuracy. This formula is much simpler to use to predict the diagonal cracking strength.
- The ACI codal formula greatly under estimates the diagonal cracking strength of the beams.
- The observed, and predicted values are compared with each other and good agreement found between them.
- Shear behaviour of ferrocement element is almost similar to the behaviour of reinforcement concrete element.
- In the absence of any codal methods of computing the shear strength of ferrocement, the expressions given in ACI for calculating the shear strength of reinforced concrete have been used. It is noticed that, the procedures given in

the code shows satisfactory agreement and are conservative. The proposed characteristics strength equation has been found to be more conservative in predicting the cracking shear strength when compared with the ACI.

## SCOPE FOR FUTURE WORK

- Studies can be extended to the shear strength of fibre reinforced and lightweight fibre reinforced ferrocement.
- Studies can also be extended to prestressed ferrocement elements.
- Behaviour of ferrocement in shear under reputated loading can be examined.

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